THE IMPLEMENTATION OF CONSTRUCTABILITY: A PREREQUISITE IN RAISING THE QUALITY OF PROJECT OUTCOME

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The success of a project is of importance not only to all parties working within a country's construction industry but also to those for whom the built environment is provided. A factor which can significantly affect project outcome is the relationship between design and construction. The weakness of the link between these activities can affect constructability resulting in problems such as delays and increased costs. An awareness of the interdependency between design and construction is an important prerequisite to promoting their closer integration and thereby obtaining the benefits of constructability. A critical review of the literature on design and constructability is related to a study of the Turkish construction industry. The Turkish construction industry reflects the profile of the UK construction industry, as it has a strong sector of large companies working in the international market and a sector comprised of small locally-based companies. The research evidence supports the conclusion that within the Turkish construction industry the constructability issues are being addressed by large scale companies, but not by small companies. Improvements in education and the strengthening of the national economy are required to raise the standard of project outcome within small companies and improve the implementation of constructability.

Keywords: constructability, design, project development.

INTRODUCTION

There is an awareness that improvements are required in any construction industry to combat inefficiency and lack of quality. Despite successful individual attempts at initiating improvement, it is not always possible to disseminate this knowledge. Therefore clients often obtain reduced value for money and the industry faces the problem of an inefficient use of resources. Research indicates that a significant factor in promoting improvements is constructability, defined by CIRIA (1983) as "the extent to which the design of a building facilitates ease of construction subject to the overall requirements for the completed building". Illingworth (1984) suggests a further definition, namely "by constructability is meant design and detailing which recognize the problems of the assembly process in achieving the desired result safely and at least cost to the client". The integration of construction knowledge into the design stage is accepted as being the most important activity to promote the implementation of constructability (O'Connor *et al.* 1987). The separation of design and construction is exacerbated by specialization due to technological improvements, the different working methods of consultants and contractors and role fragmentation. Other barriers to the implementation of constructability include a lack of awareness of its concepts and benefits, the limitations of procurement methods, a lack of feedback systems, a lack of team building and partnering (O'Connor and Miller 1994). This

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paper explores the relationship between design and construction, defining those principles which promote their integration, and examines the use of these concepts within the Turkish Construction Industry, identifying factors unique to this industry.

THE BIRTH OF CONSTRUCTABILITY

An early reference to constructability is found in Vitruvius who underlines the need to combine theory, which corresponds to design, to practice, which relates to construction (Moore, 1996). The separation between design and construction began after the Renaissance, when architects began to differentiate their role as practitioners of the liberal art of decoration from those who were practitioners of the mechanical art. This separation was reinforced by the Industrial Revolution with modern engineering techniques contributing to project complexity and the fragmentation of roles (Felix and Georgina 1998). The Emmerson Report (1962) was one of the first to examine constructability in the UK with regard to the lack of a close relationship between the architect and constructor. The 1960s and 1970s were the periods in which most of the construction industries in the world experienced failures in providing projects efficiently, at the appropriate cost and of a satisfactory quality. The complexity of today's projects has led to increased specialization, and the growth of legislation exacerbates the fragmentation and isolation of the design and construction stages. In the past, experienced professionals were usually capable of eliminating constructability problems on site (Mansfield 1983). The need for constructability has emerged in parallel with the increase in complexity of construction processes and applications of various plant, whose cost and performance are directly affected by the smooth sequence of different operations (Illingworth 1984).

FACTORS AFFECTING CONSTRUCTABILITY

Research indicates that a very wide range of factors can promote constructability including the design efficiency, education, feedback systems, an awareness of the importance of early design decisions and the establishment of suitable conditions to promote the integration of design and construction. Fisher *et al.* (1997) emphasize the significance of early communication between the designer and contractor, and as this is regulated by contractual relationships the choice of suitable procurement methods is extremely important (Griffith and Sidwell 1995). Illingworth (1984) also emphasizes contractual obstacles, focusing on the current forms of contracts in the UK construction industry which prevent the contractor from being involved at the design stage. A collaborative contractual environment can be promoted by the use of, for example, construction driven information schedules (Eldin, 1998). Simplifying the design through standardization, component reduction and the use of straightforward jointing methods can improve design efficiency in terms of constructability. Standardization which results in repetitive activities also improves learning curves and productivity. Prefabrication reduces site time, the effect of adverse weather and errors due to poor working conditions. However, these concepts need to be supported by a clear communication structure.

Awareness of the benefits and concepts of constructability is relevant for all parties within the project development process (O'Connor *et al.* 1994). Designers, architects especially, are blamed for not possessing the necessary knowledge of construction methods and how their efficiency can be affected by specific conditions (Fisher *et al.* 1997). Research indicates that constructor-architect education programmes would motivate them to take constructability into consideration while designing (Moore

1996). Mansfield (1983) criticizes the education system for not informing the future professionals of the realities of site construction. Allsopp (1983) comments that the architect can only perform adequately in terms of constructability if creative ideas are considered equally important. In an adversarial environment, this problem of constructability can be exacerbated by the contractors' response to the situation in which he tries to benefit financially from the faults of others. Additionally there is an imbalance between the contractor's priorities and those of the architect. Clients also create barriers to constructability by being reluctant to invest money and effort in the early stages of a project and through a lack of understanding of its concepts (O'Connor *et al.* 1994). Researchers in the industry consider that an improvement in constructability is related to the use of Value Engineering (Russell *et al.* 1993). These subjects are thought to be interdependent, as a function of both is to improve the integration of design and construction.

The achievable improvement in project outcome is related to the extent to which repeated mistakes can be avoided. Therefore, lessons learned need to be integrated into future projects by establishing feedback systems. Most systems are limited by poor communication between experienced and inexperienced personnel, the relationships between parties, and a lack of accessible classification systems with the potential for being updated (Kartam and Flood 1995). The majority of knowledge obtained by the project members is not communicated to others. Lack of efficient communication results from a lack of team building and also forms a barrier to the implementation of constructability, leading to deficiencies in production information. The effect of barriers impeding the implementation of constructability is considered to be company specific. The sources of barriers are distributed equally between the client, designer and contractor and can be categorized into cultural, procedural and incentive groupings. The potential for improvement is affected by the attitudes and behaviour of these main parties. Interestingly their attitudes are in turn affected by the lack of integration of design and construction and this division becomes the barrier to their integration, making the problems more complex (O'Connor *et al.* 1990).

According Eldin (1998) a project can benefit more from a constructability program performed at the beginning of the conceptual design stage and these benefits are likely to increase if the program is continued throughout the project. Fischer *et al.* (1997) in their work propose a system, which would promote constructability through a combination of benchmarking and feedback by which specific projects could be checked and improved. Project cost can be reduced by a contractor sharing his construction knowledge. However, designers may consider that contractors, who participate in a design team, are challenging their role (Kartam *et al.* 1995).

THE TURKISH CONSTRUCTION INDUSTRY – AN OVERVIEW

After the War of Independence the infrastructure, schools, hospitals and factories of the new Republic of Turkey were built. These developments continued, supported by industrialization programmes during the 1930s. During the 1950s, foreign firms carried out many large-scale projects such as dams and industrial complexes, and this provided experience for Turkish engineers. In the 1960s, Turkish companies began to increase their market share. As a result of the Turkish-Greek Cyprus War, funds from the USA and United Nations were reduced and an embargo was put on Turkey (Tavakoli and Tulumen 1990). However, Turkish firms successfully sold their services abroad and partnerships were established with international companies. Legislation encouraging overseas activities was passed in 1979 increasing their share

of this work. By the mid-1980s projects in the Middle East had slowed down due to falling oil prices and the Turkish economy was suffering from many problems as a result of high rates of inflation, a trade deficit, inadequate natural resources and international debts. Military forces took control and introduced a number of economic reforms, added to by the civil government elected in 1983 (Tavakoli *et al.* 1990). The Turkish construction industry underwent its third significant period of expansion due to the establishment of the Mass Housing Fund in the 1980s and the construction of large infrastructure projects. After the cold war ended, new markets within the former Soviet Union opened up. New opportunities for Turkish contractors which had emerged with the end of the Iran-Iraq War in 1988 were lost due to the Iraqi invasion of Kuwait in 1990 and the subsequent Persian Gulf War in 1991. The effects of these events were aggravated by the 1994 economic crisis and the growth of the industry slowed down. This recession affected the residential sector rather than the commercial and industrial sectors. In addition to privatization, projects supported by the government have helped the industry to recover. Additionally the growing population, the migration from town to city, economic growth and a decrease in the size of today's Turkish family has promoted urbanization, creating a demand for housing and infrastructure. Tourism is promoting development especially in coastal cities (Sectoral Analysis, 1998). Today Turkish contractors have a share of about 10% of the international market (Contracting Activities Abroad, 1999).

The Turkish construction industry is formed mainly of small companies, whose number exceeds 30,000. However 70-80 companies share 80% of local and 100% of international projects (Sectoral Analysis, 1998). Some of these companies are within the Top 225 International Companies' list, which is published by Engineering News Record, and most encompass several different companies operating in industries such as tourism, banking, marketing, import and export, and manufacturing of construction materials. Contractors require a licence and a technical proficiency certificate from the Turkish Ministry of Public Works and Resettlement. The Ministry also classifies contractors thereby limiting the size of project for which they can tender. Partnering has been established widely in the subcontractor sector (Tavakoli *et al.* 1990). The contracts used in the industry are mainly of four types: competitively bid, negotiated, build-operate-transfer (BOT) and mutual construction. In the private sector negotiated contracts are preferred. In addition contracts based on mutual benefit are commonly used in residential and commercial projects, under which landowners give their land to contractors in return for a share in the building. Due to problems in selection procedures for public projects, competitive bidding was restructured in October 1983. The main criteria for awarding a contract are now, in addition to cost, the qualification, reputation and experience of the bidder.

It is compulsory for every professional, with the exception of government officers, to belong to the appropriate professional association. The Union of Chambers of Turkish Engineers and Architects (UCTEA) was founded in 1954, and has more than 23,000 registered members. This institution also checks and certifies projects within the industry. The professional institutes determine minimum fees. However these are open to negotiation. In the public sector most professionals are employed by the Ministry of Public Works, whilst in the private sector professionals are employed by the construction and design companies (Civil Engineering Education and Activities, 1995). Education is provided at two levels: Bachelor of Science and Master of Science. There are 25 Universities providing a BSc programme (Civil Engineering,

1995). There has been an increase in the number of universities in recent years, creating a scarcity of suitably qualified academic staff.

The problems of the industry identified by Adiloglu (1994) and others are in the areas of education, organization and management, the carrying out of feasibility studies, preparation of information, tendering procedures and regulations, and programming. Economic problems are prevalent in the construction industry. Funding development projects through borrowing, which is one of the methods of solving some economic problems, has only recently been available in Turkey.

RESEARCH METHODOLOGY

Data were collected using detailed questionnaires of which the respondents had prior knowledge. The questions were designed to investigate their experience and constructability knowledge. In addition other topics investigated included the role of design, and to what extent those in the Turkish construction industry were aware of constructability concepts, benefits and barriers to its implementation. The sample was chosen to reflect two main types of companies, namely designers and contractors. A system of categorization was devised in which each respondent was assigned a code identifying their company profile, range of projects undertaken and experience. 25 companies were approached of which 21 agreed to partake in the research. 13 respondents work in both private and public sectors, 9 in the private sector and 2 in the public sector. 17 have an annual construction volume of more than $25,000,000. Three-quarters of the respondents had been in the industry for over 25 years.

ANALYSIS OF DATA

The respondents agreed that constructability is the use of construction experience in planning and design to achieve an efficient and cost effective outcome which meets the project's criteria. One respondent preferred the term "effective constructability". One fifth of the respondents used a formal constructability programme, agreeing that implementation in the early design stages is of most benefit, achieving a better outcome, and improving competitiveness and productivity with the establishment costs being compensated for by the financial benefits of early completion and enhanced reputation. Those without a formal programme considered them unnecessary, although their responses showed that they did participate in activities promoting constructability. Following this their involvement in briefing, advising on tendering and procurement methods, integrating design and construction information, creating feedback, and participating in demonstration projects and training was investigated. It was found that all the architects, and the majority of design-build contractors, participated in the briefing stage. It was found that it was rare for the respondents to advise on tendering issues and procurement and whilst all collaborated in determining programming the client's dominance results in tight schedules. Two thirds of the respondents had never participated in a demonstration project and this concept did not appear to be fully understood. It was considered to be a simulation project, by some thought a useful tool for professional education, by others perceived as an academic activity.

Respondents considered that if clients consulted them about the employment of consultants and others, good team-working was more likely to result which would promote the co-ordination of disciplines. Project success was believed to be directly related to the effectiveness and compatibility of production information. Designers

advised on these issues more often, whilst the request for contractors' advice depended on project, contract and client type. The reasons given for inefficient information included the reuse of specifications which did not match the current project's needs, a lack of checking procedures and a lack of a designer's representative on site.

The concept of integrating construction information into the design phase was considered essential and the separation of design and construction was seen as the most important barrier to the implementation of constructability worsened by the specialization and fragmentation of roles. Most considered designers to be responsible for developing their construction knowledge and reviewing the constructability of designs on site so as to accumulate experience. It was felt that those who had not been involved in the construction process were unable to create buildable designs even with a contractor's input. Although it was suggested that consultants, such as project managers, could be used to achieve the integration of construction knowledge, this was rarely done as there is a preference for relying on one's own experience, and avoiding the cost. The point was made that in the Turkish Construction Industry, design was not always as respected as elsewhere and designers were therefore restricted in their abilities to employ specialist consultants. Attitudes to designers were found to differ: some favoured them having unlimited freedom to create and some saw the main purpose of design as meeting a need. Designers were found to be critical of engineers and contractors for being conservative, while the others blamed designers for being Utopian. There was a lack of understanding of each other's viewpoint. Respondents added that constructability is directly related to resources in terms of workforce, equipment and materials and that this knowledge should also be integrated into the design. Especially in the global industry, a designer’s lack of knowledge of resource availability is a problem in projects whose initial designs are prepared overseas. For example taking into account adverse weather conditions was deemed unimportant within Turkey, but important for overseas work. The comments reflected the nature of the respondents' project base, different factors being given more prominence according to the country in which the construction takes place.

The creation of feedback was thought crucial in facilitating continuous improvement for the individual and organizations. However all indicated that there were difficulties in passing on experience and knowledge. In the Turkish Industry, feedback depends on personal abilities and initiatives and having senior managers with an ability to communicate, who are active archives. However relying on them limits the extent of dissemination. Respondents commented that some managers incorrectly perceive that systems which require the recording of experiences and training of the workforce are costly, ignoring their long-term benefits. The entrenched attitudes and low fees for design services preclude the funding of data recording and developing feedback skills.

Education was focused upon as significant in improving industry standards. Designers were believed to be less well educated than in previous decades. Academic education for all construction disciplines was perceived as emphasizing ideas and theoretical issues, and not preparing future employees for practice. Academics were criticized for lagging behind current technology and not understanding contemporary issues. Solutions to this were considered to be the incorporation of concepts such as Value Engineering (VE) within the curriculum and focusing equally on constructability and aesthetic issues. The point was made that continuing professional education also had an important role in expanding knowledge. It was believed that construction, a core industry, is affected by socio-economic factors controlled by

political changes, making it volatile and risky, resulting in a reduction in non-essential activities. The history of the industry indicates that whenever the sector is financially stable, money is spent on professional education.

The education of the workforce was deemed to affect constructability and quality. Respondents commented that education was achieved through carrying out work; productivity and quality thus reaching acceptable levels through repetition. Training initiatives were not always successful due to the workers' preference for employment on a project-by-project basis. Workers returned to rural areas in harvest time and contractors were reluctant to train them if there was no guarantee of their return. There was lack of trade schools as their establishment requires substantial funding. Large companies with adequate resources had no difficulty in attracting the best workforce. The clerk of works generally trained workers. Some respondents believed this method to be satisfactory although the standard of education could be affected by their relationship. The respondents agreed that training is a necessity, in technical and health and safety areas especially, due to the scale of change. In addition, training improves motivation and company loyalty. The productivity of the workforce was perceived as an important factor in improving constructability and this was believed to be strongly influenced by working conditions. Although conditions had greatly improved in line with other construction industries, most improvements have been achieved only by large-scale companies and were unrepresentative of the industry in general. Reasons given for the poor working conditions are the lack of Trade Unions, the fear of unemployment, and the relationships between management and workforce.

The comments on clients' understanding of the issues involved in project development indicated that public bodies were considered experienced. Inexperienced clients being able to compensate for their lack of knowledge and difficulty in setting objectives by employing project managers. However the point was made that a balance needs to be established between directing the client to the appropriate extent and maintaining their freedom of decision-making. Difficulties were seen to arise when clients' wishes were incompatible with what could be done efficiently and late changes were made. Examples of previous projects were emphasized as useful in explaining these issues.

Standardization and prefabrication were considered by the majority of respondents to promote constructability. The decision to use standard or pre-assembled components depends heavily on the type of the project which can be adapted and even though the designer can encourage their use most respondents claimed their use also depended on the client, especially in public projects. Each project was examined in terms of the application of pre-fabricated components and the client was advised how rapid on site assembly could compensate for their extra cost.

Designers experienced client pressure to increase the rate of production of design information and this was considered to effect constructability, resulting in inadequate and incompatible information. This pressure was believed to arise from a lack of understanding of the function of the design process. The point was made that by pressurizing the design process more time was subsequently lost during the construction phase than was initially saved. Respondents cited compliance with regulations and bureaucracy as other factors limiting design time. All agreed that the use of IT could support the design process but its use in general was low and this was seen as detrimental to the promotion of constructability. Amongst the sample group the range of software used varied between that designed in-house and proprietary systems, with the designers using computerized systems more frequently. The

respondents commented that a lack of confidence in the benefits of IT was widespread among small companies.

The respondents agreed that consultations between designers and contractors are difficult to achieve due to procurement methods which, for example, result in the contractor being appointed after the design is finished, or the designer's involvement ceasing before commencement on site. The success and level of integration of construction knowledge into the design phase was considered to be directly related to the procurement method. The industry's main client, the government, prefers traditional systems which isolate these activities, and perceives them as carrying least risk and providing most value for money. The point was also made that deficiencies in contracts used with public projects create an imbalance of equity between the client and contractor. The use of alternative contract types was being promoted, such as FIDIC (Federation Internationale des Ingeneieurs Counceils) which was preferred by all parties, as it could be amended to be project-specific thus improving productivity and constructability. Design-build was also highlighted as an appropriate method to support constructability and team building.

The majority of the respondents agreed that a lack of team working is a barrier to the implementation of constructability, resulting in poor co-ordination, organization and communication. These factors were seen as being especially important for the main parties in a project, namely the client, designer and contractor. Problems concerning co-ordination were seen to increase, in extensive and complex projects for which a larger group of specialists is required. Team working was thought not only necessary for projects involving different companies, but also essential for a multi-disciplinary company, and should be extended to collaboration between design office and site. Team success was thought to be strongly dependent upon the level of knowledge and experience of its members and whether or not they reach decisions through mutual agreement, which in turn relies on leadership. Entrenched attitudes, which include a reluctance to delegate implying a lack of trust in others' abilities, were seen as detrimental to team working. Partnering, which encompasses team building and mutual goal setting in a non-adversarial environment was generally accepted as a positive concept which should be promoted. VE was accepted by all respondents as a very beneficial activity and its lack of use as a barrier to constructability. However, its implementation was seen as a low priority, and there was little optimism that its use would increase due to cost and time implications. VE was seen as a relatively new concept and the culture created by the socio-economic conditions precluded its increased use.

CONCLUSIONS

The data collected represent the views of a range of larger companies who, apart from their international client base, dominate the local market. It is recognized that they are not representative of the whole industry. They acknowledged that, due to their experience and client base, barriers to constructability were not necessarily relevant for their companies but were valid for the industry as a whole. The respondents agreed that the main barriers to constructability are as described in the literature. They highlighted those factors, which they see as especially detrimental to the integration of design and construction. These include procurement methods, a lack of equity in contracts, a lack of team building and the time pressure on the design stage. The respondents perceived some barriers as being unique to the Turkish construction industry. These include a lack of training of the workforce due to the lack of

permanency in employment, poor working conditions, a general lack of education at all levels within the industry and a culture precluding delegation and the use of procedures such as VE. Some difficulties were considered to result from purely contractor related factors, including unrealistic bidding, using inappropriate construction methods and neglecting supervision. Material related constructability problems were commonly experienced in international projects.

The respondents proposed strategies for eliminating the barriers to constructability implementation. These included the use of benchmarking to raise overall quality, promoting the use of contracts which avoided the separation of design and construction and promoting a multidisciplinary structure within the industry built on teamwork and partnering. Improving education and developing continuous professional education at all levels was seen as crucial to increasing efficiency and promoting the development of appropriate legislation. One factor highlighted was the relationship and interdependency between a country's socio-economic development and a core industry such as construction. Whilst larger companies have the economic base to implement strategies, smaller ones with less experience and a dependency on a local client base are more sensitive to the economic environment.

The respondents were aware of the lack of constructability, its causes and that its effective implementation depends on the application of many principles, which in turn relies on the experience and knowledge of individuals. They agreed that many in the industry have sufficient knowledge and experience to either implement internationally used constructability procedures or to develop procedures specific to their industry. However, there are political, economic and social factors outside their control which affect the potential for promoting constructability. These include the level of bureaucracy, national economic conditions, entrenched attitudes and traditional roles. An important factor was seen to be a lack of appreciation of the design process, resulting from a lack of awareness of its role in project development and an emphasis on project cost without considering value. Designers were poorly paid and moved to work in other sectors of the industry. They were then subsequently replaced by those less qualified and experienced.

This study indicates that there are core barriers to the implementation of constructability which are relevant for both the UK and Turkish construction industry. Issues raised in reports on the UK industry are reiterated in those on the Turkish industry. Findings repeatedly focus on the separation of design and construction as being the root cause of the lack of constructability. It is interesting to note the emphasis which is placed by the respondents on the need for a high level of technical knowledge on the part of designers and the importance of the design process.

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